Acoustic Communications (ACOMMS) ATD

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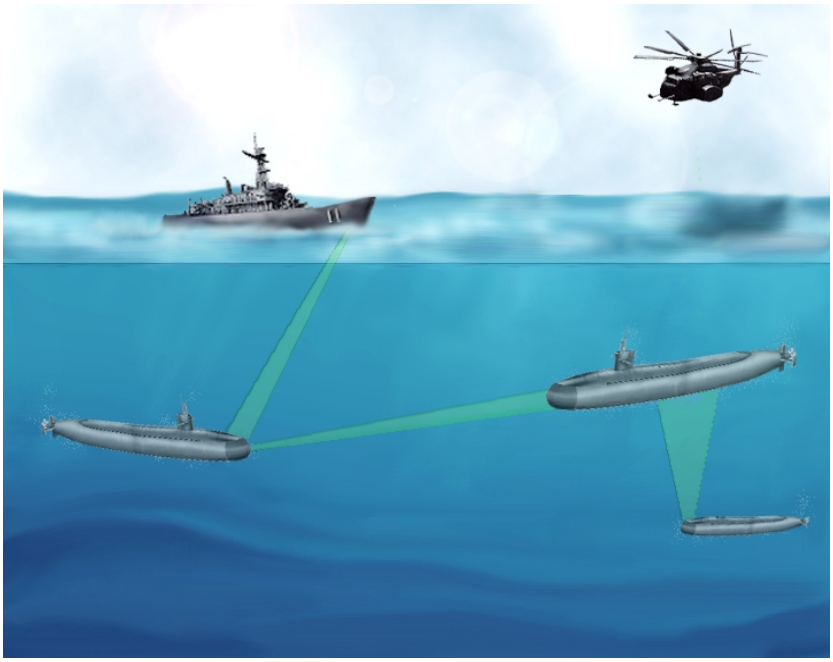
LONG-TERM GOALS

The goal of the recently completed Acoustic Communications Advanced Technology Demonstration program (ACOMMS ATD) was to demonstrate long range and moderate data rate underwater acoustic communications between a submarine at speed and depth and other tactical platforms. This capability, as a component of Battlespace Connectivity, has repeatedly been identified as one of the highest priority COMSUBLANT/COMSUBPAC Command Capability Issues (FY97, FY98 and FY99).

OBJECTIVES

The primary objective of the ACOMMS ATD was to develop and demonstrate emerging undersea acoustic communication technologies at operationally useful ranges and data rates. The secondary objective of the ACOMMS ATD was to develop a fleet-compatible advanced acoustic communication capability that can easily be transitioned into planned Fleet Commercial Off The Shelf (COTS) upgrade programs.

Under this program, the ACOMMS ATD has demonstrated the potential to provide a reliable, robust, moderate data rate acoustic communications capability for tactical use between submarines, surface combatants, unmanned undersea vehicles (UUVs), and other platforms.



1. ACOMMS Concept

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This communications capability includes the transmission of text data, compressed images, and digitized voice from one operational unit to the other on a real-time (not including propagation time) basis. This has been demonstrated both at high frequency/high (acoustic) data rate over short range (2.5 nm - environmentally dependent) and at medium frequency/moderate data rate at long range (35 nm - environmentally dependent).

APPROACH

The ACOMMS ATD has demonstrated an underwater acoustic communication capability that is free from the distortion associated with multipath interference, thus allowing for tactically useful digital telemetry under appropriate acoustic conditions (adequate SNR at the receiver).

A two phased approach was taken for this ATD. An existing PC-Based Modem System, previously developed by the Government through the Defense Advanced Research Projects Agency (DARPA)/ Woods Hole Institution (WHOI) research, was provided as Government Furnished Property (GFP) to the ATD program. This served as the technical starting base for the development of the VME-Based Modem hardware, as well as an interim development tool for upgrading of the baseline acoustic communication algorithms. The VME based modem system represents the final prototype of the ATD. The COTS based design afforded both adequate design growth and provides the basis for the

2. ACOMMS VME Based Modem

subsequent rapid insertion of acoustic communications capability into Naval sonar systems.

In addition to the ACOMMS modems and imbedded algorithms, unique interfaces and COTS receiver preprocessing (beamformers) were developed to interface the ACOMMS modems to the HFSP and BSY-1 submarine, and the AN/SQS 53C surface combatant sonars. The transmit and receive

characteristics of these sonars are essential to achieving the ranges and data rates mandated by the ATD exit criteria and required for tactically useful communications.

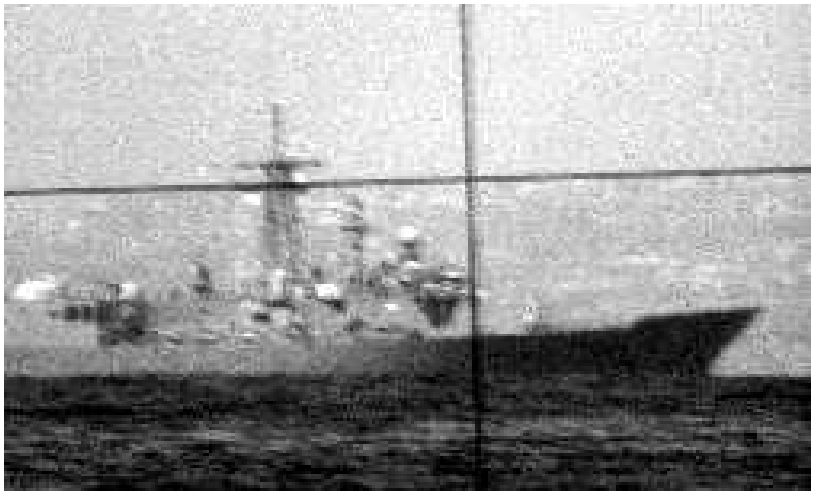
A series of formal at-sea tests and demonstrations have been conducted during the course of this ATD allowing both the PC-based and the VME-based modem systems to achieve their specific objectives through an incremental and iterative process. These at-sea tests, augmented by a series of supporting tests, have demonstrated how well the system design performs under a variety of operational and environmental conditions, and have verified that the ATD exit criteria have been successfully met. The final demonstrations were explicitly designed to show potential inter-connectivity among submerged, surfaced, and other platforms.

WORK COMPLETED

In FY99, the ATD conducted several successful demonstrations using high and mid frequencies acoustic communications between tactical platforms in several challenging acoustic environments.

In December 1998, a mid frequency ACOMMS demonstration between the AN/BSY-1 equipped USS ALEXANDRIA (SSN 757) and the RV CAROLYN CHOUEST was conducted in deep and shallow waters of the Narragansett Bay Operation Area. Digitized voice, text and images were transmitted and received in real-time to ranges greater than 35 nmi, at several data rates and at significant differential Doppler while the submarine operated at speed and depth.

In April 1999, the ATD participated in Fleet Battle Experiment Echo (Limited Objective Experiment) in the Southern California Operating Area. The ability to exchange digitized voice, text and images between the USS COLUMBIA (SSN 771) and the USS JOHN PAUL JONES (DDG 53) at significant ranges, data rates and differential Doppler was demonstrated in both deep and shallow water. Images exchanged between both platforms at 35 nmi apart were decoded real time in 50 seconds (Fig. 3 & 4).

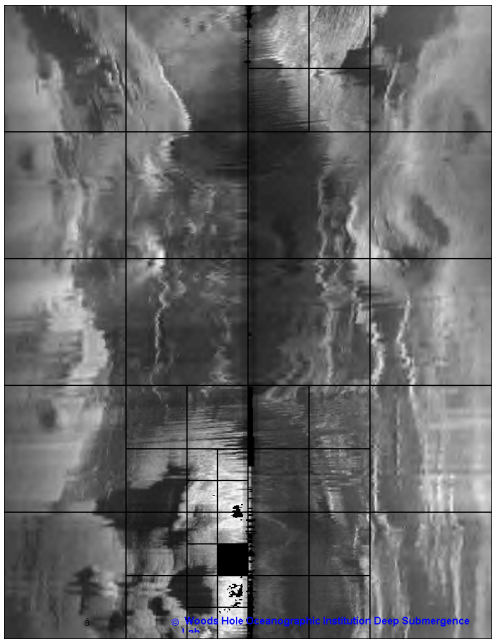


3. FBE-E: Image Received on DDG, Sent by SSN

4. FBE-E: Image Received on SSN, Sent by DDG

At the request of the OPNAV sponsor, battlegroup connectivity was demonstrated using JMCIS vice LINK-11 through an ACOMMS/JMCIS interface developed by the ATD. As part of the FBE-E (LOE), the ability to use ACOMMS as a revolutionary tool that allowed the battle group to coordinate the establishment of a Joint Attack Zone with a submerged submarine in a timely manner was demonstrated. The cycle time between initiation and acknowledgement was completed in less than 20 minutes.

In May 1999, two concurrent demonstrations using high frequency ACOMMS were conducted in deep and shallow waters of the Hawaii Operating Areas. One demonstration, between the USS ASHVILLE (SSN 758) and the FAU AUV MAGELLAN, involved the transfer of large data files simulating mission data from the AUV to the submarine (Fig. 5). The other demonstration, between the USS ASHVILLE and the R/V MOANA WAVE, established the ability to transfer voice, text and image data in both directions over ranges in excess of the ATD exit criteria.



5. UUV Simulated Sensor Data Received on USS ASHVILLE

During the remainder of 1999 the ATD will complete the at-sea test data analysis, wrapping up the algorithm development effort. As a follow-on ACOMMS transition effort, various manual functions related to the operation of the sonar interfaces and the set up of the modem parameters will be automated. The resulting software will be transitioned to Lockheed Martin (LMUSS) for incorporation into ARCI through the Advanced Processing Build process (APB 01). Successful completion of ABP01 is expected to lead to integration into the scheduled Fleet installation A-RCI Phase III and NSSN.

The existing ACOMMS modems and interfaces are available to support any emergent sea test or demonstration opportunities. These COTS items could readily be reconfigured into deployable "Roll-on/Roll-off " systems once the automation issues and platform specific interfaces have been addressed. Such systems could be utilized by operational platforms not currently on the transition path.

RESULTS

The ATD Exit Criteria of establishing an acoustic data link at stated ranges and bit rates for mid and high frequency transmissions were met during the at-sea tests. Error coding and other overhead established the standard information data rates for each frequency. Acoustic environments with complex or rapidly changing multipath structure impose a further reduction to medium or low data rates to preserve a robust communication link. An ACOMMS performance prediction tool developed under the ATD allows the determination of the "best' transmitted data rate in a given acoustic environment. The receiving modem automatically accommodates the data rate transmitted. Robust connectivity has been demonstrated at relative Doppler values as high as 28 knots. Results from all sea tests in FY99 are summarized in the table below. Results from the SSN-UUV HF ACOMMS will be available from WHOI at a later time. The SSN-RV (MF) Shallow test results reflect the impact of deteriorating weather on the deployment and performance of the RV source and sensors.

Test Event	Date	Receive Platform	Environment	Packet Success Rate			Min SNR	Max Range
				Std	Med	Low		
SSN-RV (MF)	12/98	SSN	Deep	77%		100%	12dB	35 nmi
		SSN	Shallow	4%		80%	6 dB	20 nmi
FBE-E (SSN-DDG MF)	4/99	SSN	Deep	81%	90%	95%	12 dB	> 35 nmi
		DDG	Deep	25%	76%	84%	12 dB	> 35 nmi
		SSN	Shallow	38%	74%	95%	12 dB	> 35 nmi
		DDG	Shallow	8%	24%	79%	12 dB	> 35 nmi
SSN-RV (HF)	5/99	SSN	Deep	68%	96%	96%	12 dB	> 2.5 nmi
		RV	Deep	40%	75%	83%	12 dB	> 2.5 nmi
		SSN	Shallow	28%	75%	83%	12 dB	> 2.5 nmi
		RV	Shallow	21%	63%	83%	12 dB	> 2.5 nmi

Where data rate is defined as follow:

Transmit Signal	Modulation Scheme	Data Rate	Information Rate
MF Stand	QPSK1250	2,500 bps	1,630 bps
MF Med	BPSK1250	2,500 bps	815 bps
MF Low	BPSK1250	2,500 bps	178 bps
HF Stand	QPSK5000	10,000 bps	6,320 bps
HF Med	BPSK5000	10,000 bps	3,260 bps
HF Low	BPSK5000	10,000 bps	712 bps

IMPACT/APPLICATIONS

Joint Vision 2010 (*JV2010*) establishes "full spectrum dominance" as the key characteristic we seek for our armed forces in the 21st century. Full spectrum dominance and its four supporting operational concepts ("dominant maneuver," "precision engagement," "full dimension protection," and "focused logistics") are utterly dependent upon Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance (C4ISR) systems that "capture, synthesize and distribute near-real time information to all levels of operations[1]."

By making rapid ("near-real time") communications with and control of all forces the key element of national strategy, national authorities increase the importance and urgency of long standing Navy efforts to fully integrate undersea forces into Navy C4ISR systems. Moreover, the new C4ISR-oriented strategy has emerged at a time when major improvements in ACOMMS systems capabilities have become practical. No other system has demonstrated the ability to communicate in near real time and at tactically useful data rates with undersea forces at speed and depth.

Other Joint and Navy requirements documents (e.g., *Joint Warfighting Science and Technology Plan*, the Navy's *Science and Technology Requirements Guidance*, the Coordinated Fleet CINC Consolidated Command Technology Issues, the *Submarine Mission Capabilities Master Plan* and derivative Master Plans, the COMSUBLANT/COMSUBPAC Command Technology Issues, etc.) describe specific mission driven capabilities objectives that would be partially or completely met by deployment of more capable ACOMMS systems.

TRANSITIONS

The acoustic communication technology developed by the ACOMMS ATD will transition to the AN/SQQ-89 (V)15/A(V)15 (MF) and the Acoustic Rapid COTS Insertion (A-RCI) Program (PE 0604503N) of the AN/BQQ-5 and AN/BSY-1 (MF and HF) for purposes of subsequent production. Transition into ARCI will be accomplished as part of the Advanced Processing Build (APB) program starting at APB01, to be tested in FY01. Any further incremental development efforts will transition to Submarine Combat System Advanced Development (PE 0603504N). Transition to NSSN will occur at Hull 3 and PSA into Hull 1 & 2 during the technology refresh points.

In addition, several other potential transitions exist for this technology, including Undersea Ranges (PE

[1] William J. Perry in Preface to Department of Defense, Director, Defense Research and Engineering. (1996). *Defense Science and Technology Strategy.*

0204571N), SURTASS Ship (PE 0204313N), ADS (PE 0604784N), Fleet Communications (PE 0204163N), AN/WQC-2 and AN/WQC-6 replacement upgrade, and various potential uses within UUV development programs.

RELATED PROJECTS

REFERENCES

Acoustic Communications ATD Program Execution Plan, ASTO
Acoustic Communications Concept of Operation Document, ASTO